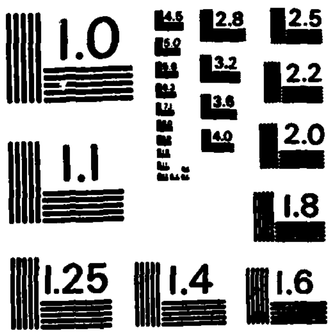
AD-A121 514 PHYSICAL OCEANOGRAPHIC SUMMARY FOR THE GULF OF MAINE/GEORGES BANK(U) NAVAL OCEAN RESEARCH AND DEVELOPMENT ACTIVITY NSTL STATION MS D A BURNS SEP 82 1/1

UNCLASSIFIED NORDA-TN-157 F/G 8/3 NL

END

FILMED

DTIC



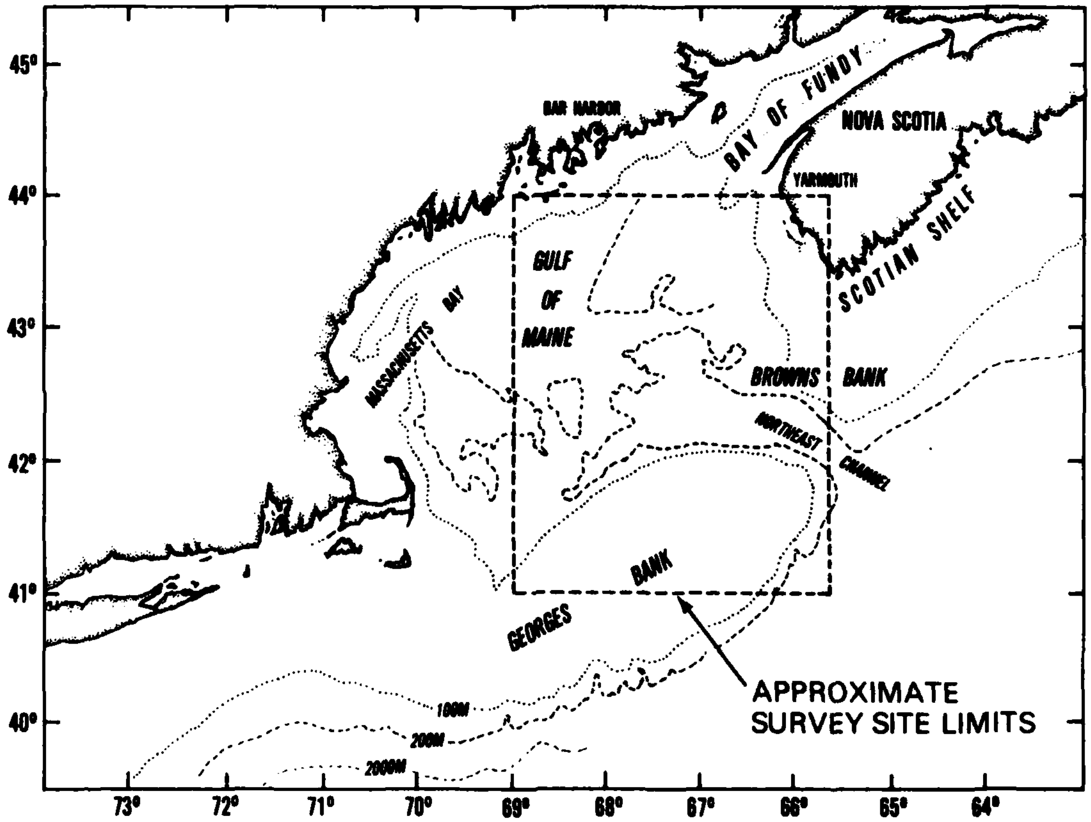
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

(12)

NORDA Technical Note 157

Naval Ocean Research and Development Activity
NSTL Station, Mississippi 39529

Physical Oceanographic Summary for the Gulf of Maine/Georges Bank



D.A. Burns

Ocean Science and Technology Laboratory
Oceanography Division

September 1982

Acknowledgement: Funds (6.2 Shallow Water Block Funds) for this study were provided by Dr. W.B. Moseley, Code 5120, Naval Research Laboratory

FOREWORD

This report was compiled to provide the Naval Research Laboratory with oceanographic environmental support data for its upcoming acoustical experiment in the vicinity of the Gulf of Maine/Georges Bank area during late 1982.

This report provides   Discussed is

ABSTRACT

~~I provide~~ the Naval Research Laboratory with oceanographic environmental data to support an acoustical experiment in the Gulf of Maine/Georges Bank region. ~~I discuss~~ marine climatology, surface waves, water masses, circulation, and ship traffic density. Using these environmental data as guides, ~~I recommend~~ that the most satisfactory exercise area would be north of Georges Bank, i.e., in the Gulf of Maine north of 42°N and west of 67°W.

it is recommended

CONTENTS

ILLUSTRATIONS

PHYSICAL OCEANOGRAPHIC SUMMARY

FOR THE GULF OF MAINE/GEORGES BANK

I. INTRODUCTION

The study area is characterized as a unique oceanographic region, rich in marine life, and with highly variable oceanographic conditions. The waters in and adjacent to the study area support a large commercial fishing industry and serve as the spawning area for many species of marine life.

Based on topography differences the proposed site area (Fig. 1) may be divided into the deep basin of the Gulf of Maine and the shoal regions of the several banks and shelves throughout the study area.

The waters of the Gulf of Maine regularly mix and interact with the waters of Georges Bank, and with the shelf/slope water masses. Due to the geomorphology, highly saline slope waters intrude into the bottom layers of central areas of the study region. Relatively low saline outflow from local rivers creates a high static stability in the near surface waters throughout most of the coastal waters of the region.

At depths greater than about 75 meters (m), a cold intermediate (2°C to 8°C) depth layer is formed by winter-cooled water overturned and maintained through the summer by the general absence of strong vertical mixing. In depths shallower than about 75 m, well-mixed water occurs throughout the year. Surface temperatures on Georges Bank and other shallow areas tend to be warmest during late autumn due to vertical mixing (Godshall, et al., 1980).

The study region lies in a zone of prevailing westerly winds that dominate the northeastern United States.

Current circulation is composed of a clockwise flow in the Georges Bank region and a counterclockwise flow in the Gulf of Maine. Strong semidiurnal tidal currents, density effects, wind stress, and other variables modify the mean circulation pattern (Butman, et al., 1981).

II. MARINE CLIMATOLOGY

The Gulf of Maine and Georges Bank lie in a zone of prevailing westerly winds that are under the influence of two semi-permanent pressure centers: the Icelandic Low and the Bermuda-Azores High which dominate the area (Bishop, et al., 1981). During winter, the Icelandic Low strengthens and the prevailing winds shift to the northwest. During summer, when the Bermuda-Azores High dominates, southwesterly winds generally prevail over much of the area. Although wind speed and direction are variable throughout the year, less variability occurs during summer. Highest wind speeds occur during winter. Figures 2 through 5 illustrate the prevailing surface wind circulation throughout the year.

III. SURFACE WAVES

A seasonal pattern of large (>3 m) waves propagates from the northwest and west during winter, and significantly smaller waves (<2 m) propagate from the south and southwest during summer (Godshall, et al., 1980).

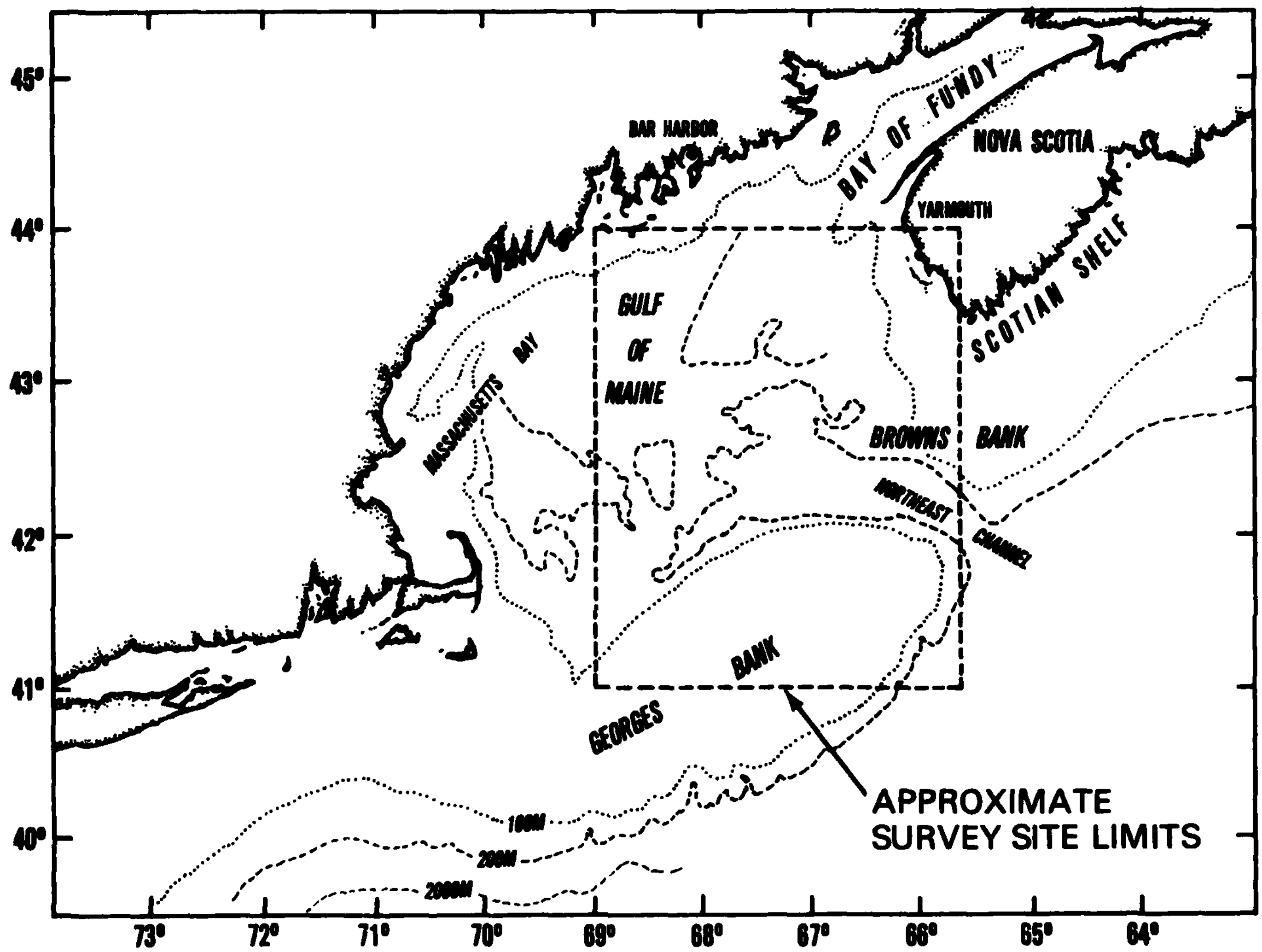


Figure 1. Site Chart (Pawlowski, 1978).

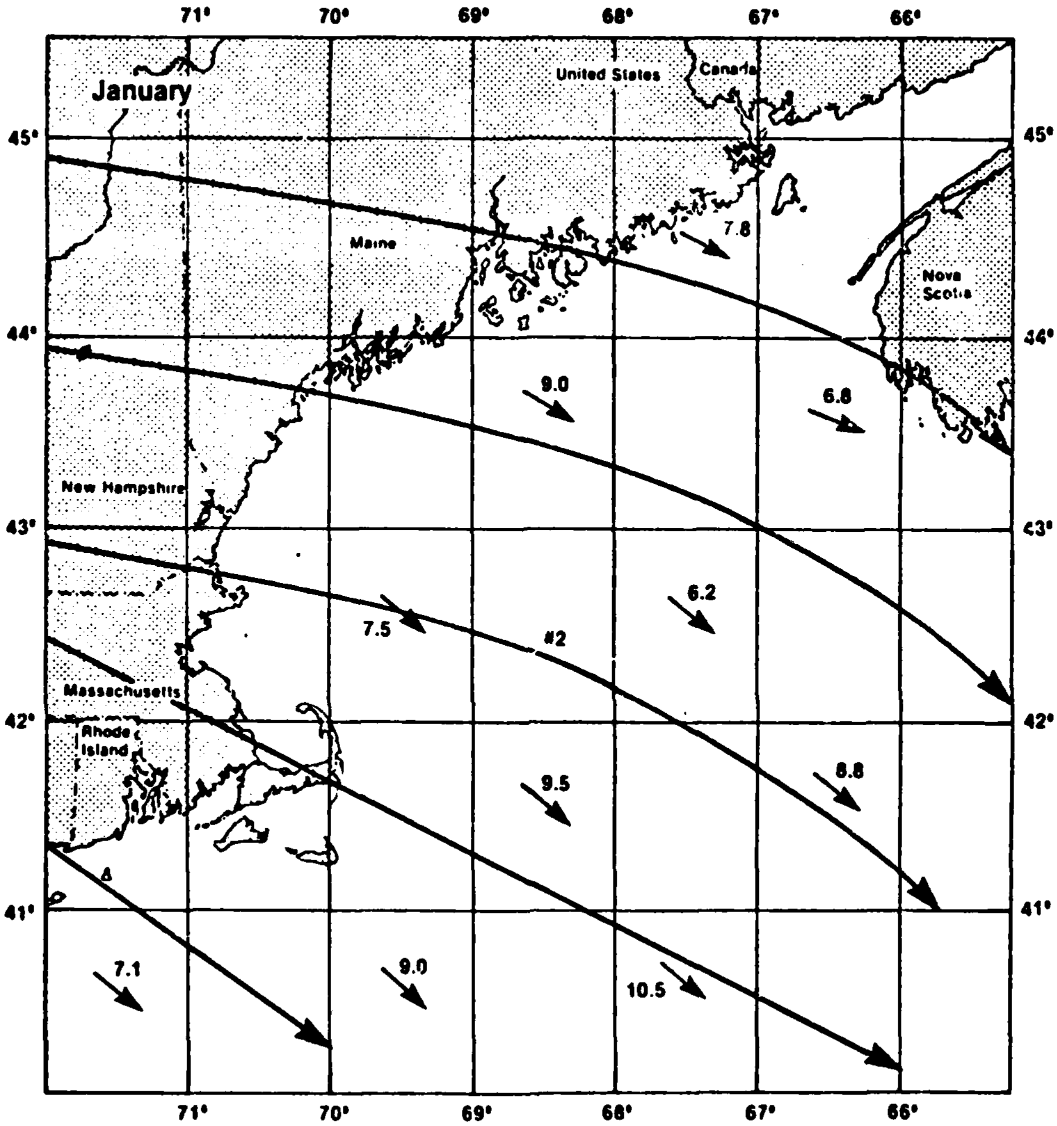


Figure 2. Winter Mean Wind Vectors in Knots (after Goshall, et al., 1980).

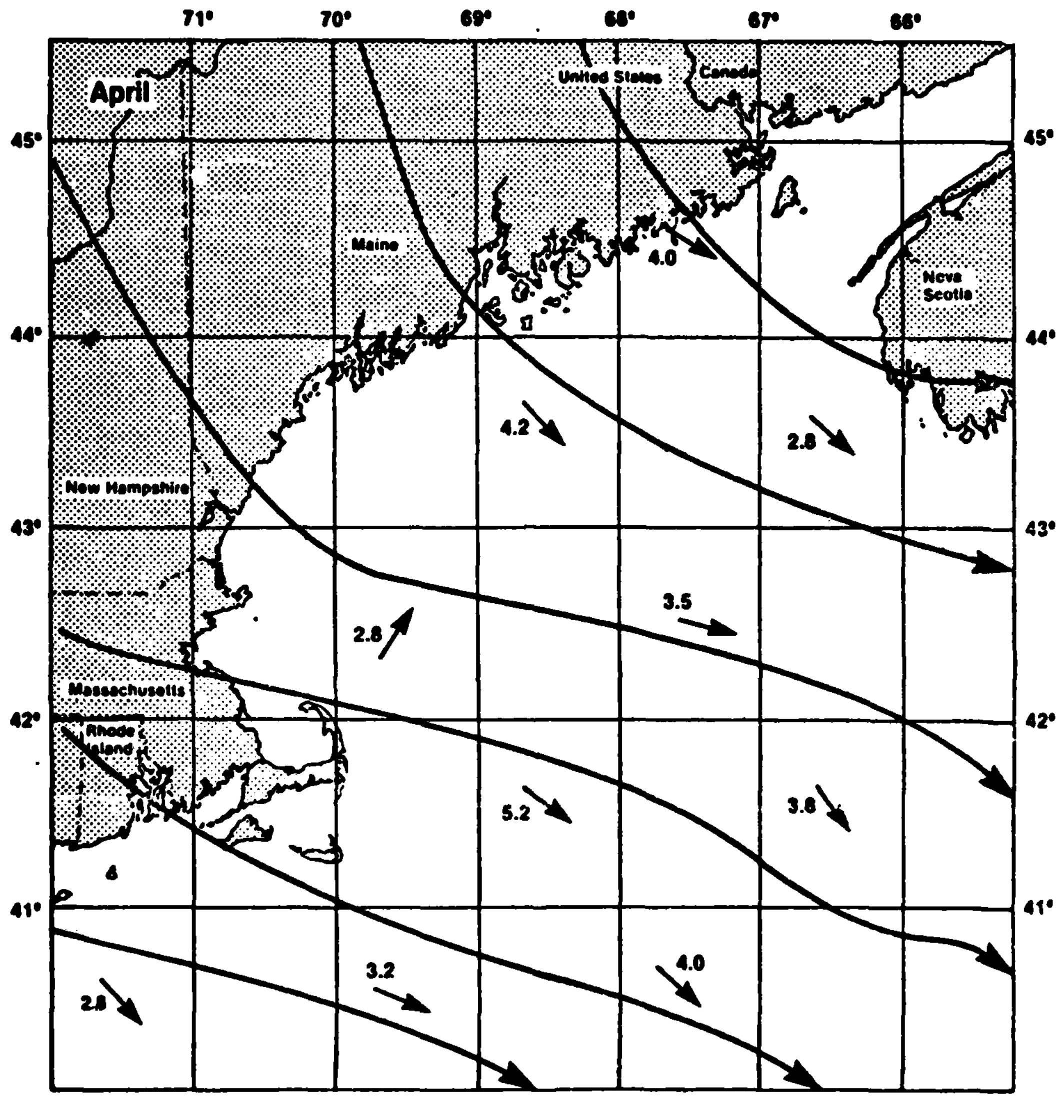


Figure 3. Spring Mean Wind Vectors in Knots (after Goshall, et al., 1980).

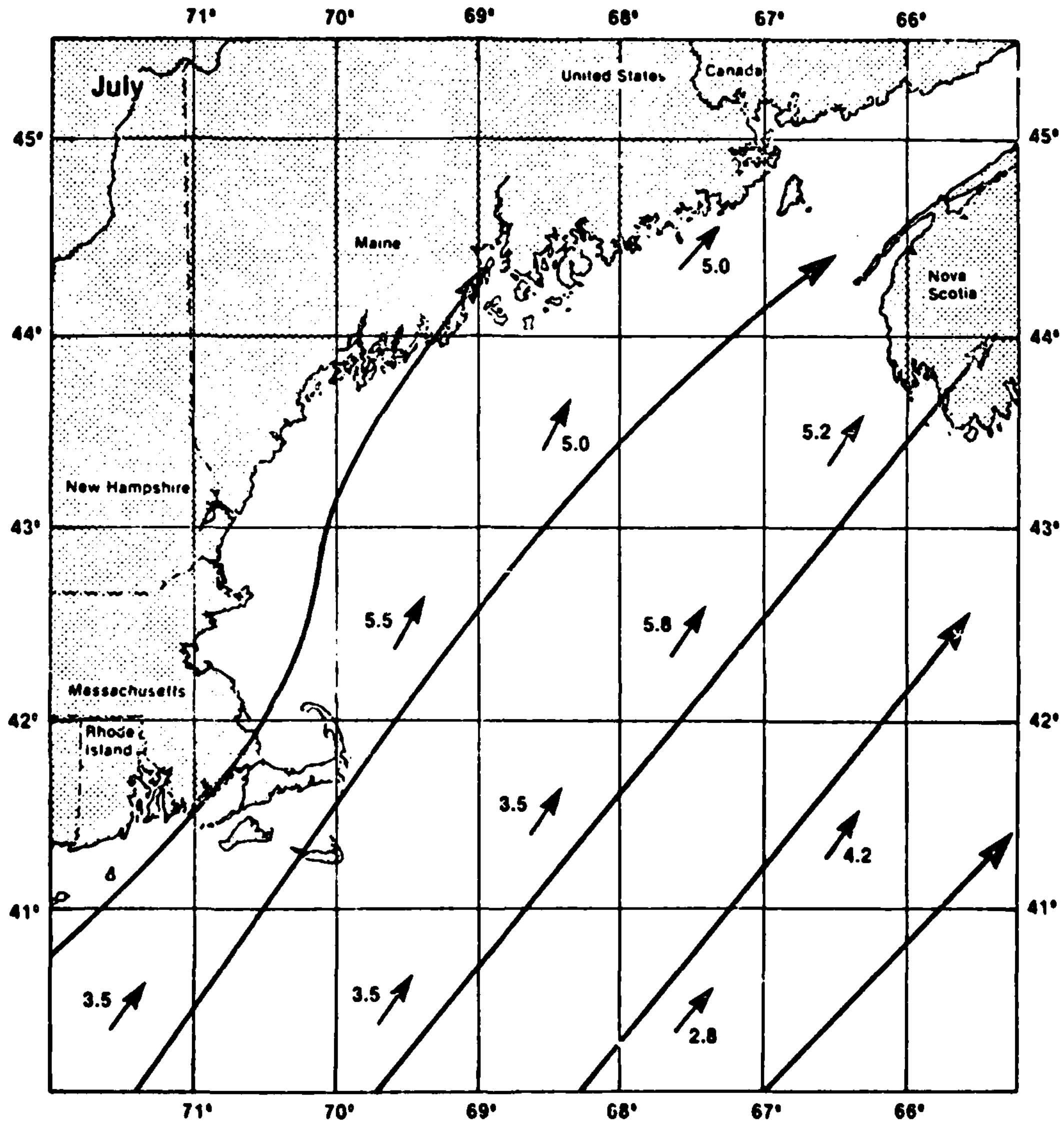


Figure 4. Summer Mean Wind Vectors in Knots (after Goshall, et al., 1980).

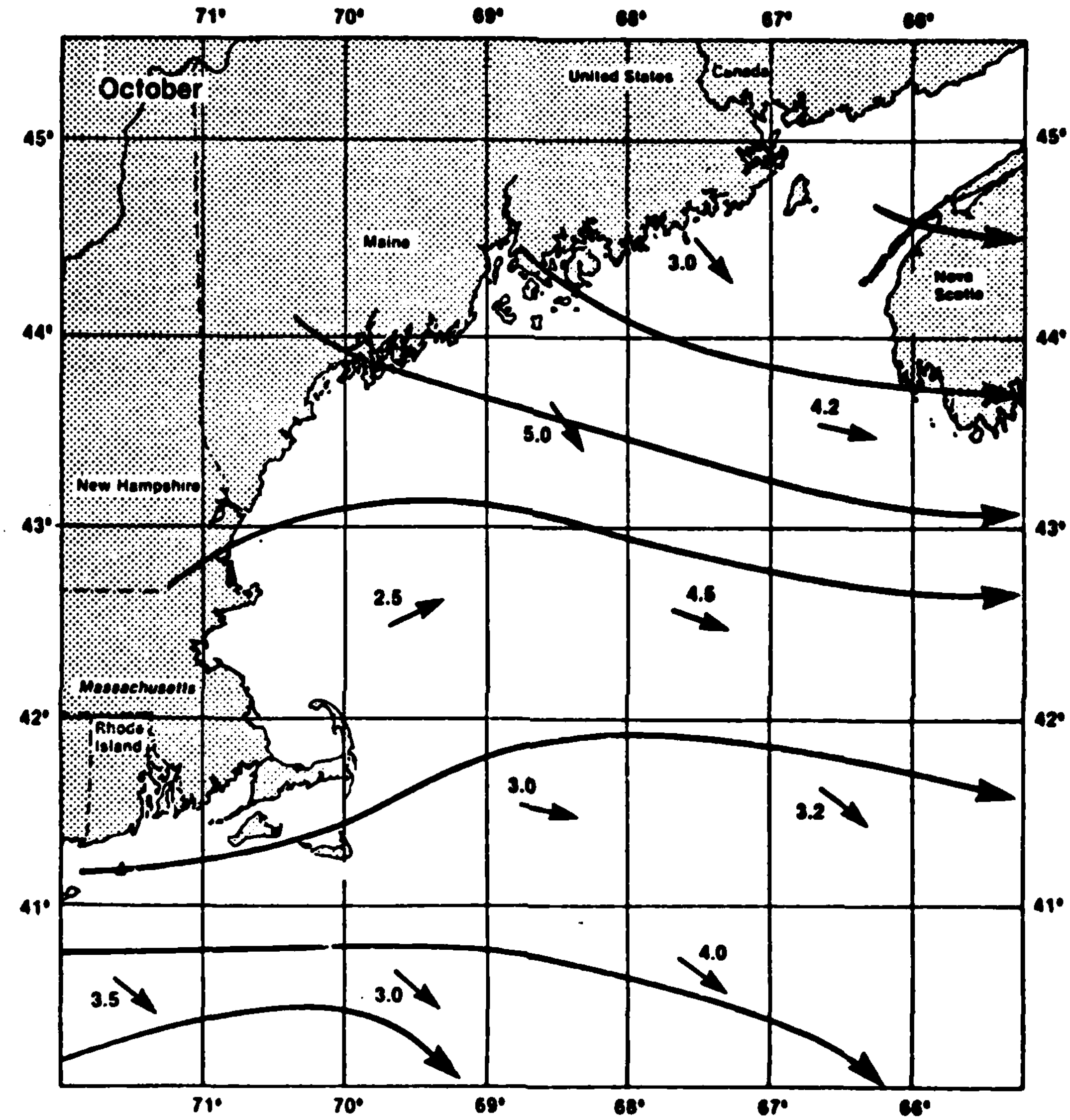


Figure 5. Autumn Mean Wind Vectors in Knots (after Goshall, et al., 1980).

During winter the Gulf of Maine becomes fetch limited in the west and northwest direction, and the frequency of occurrence of large waves is reduced as compared to Georges Bank (Fig. 6).

According to Bishop, et al., 1981, the predominant wave heights are about 2.0 m during winter and about 1.0 m during summer over most of the area.

IV. WATER MASSES

The waters within the study area can be grouped into several water masses (Fig. 7): Maine Surface Water (MSW), Maine Intermediate Water (MIW), Main Bottom Water (MBW), and Georges Bank Water (GBW). Upper Slope Water (USW) and Lower Slope Water (LSW) are found seaward of Georges Bank. The temperature-salinity (T-S) relationships of these water masses, according to Hopkins, et al. (1977), are indicated in Figure 8. Figure 9 locates several oceanographic transects that have been occupied on a seasonal basis.

In depths less than about 60-75 m the water column is vertically well mixed throughout the year by strong semidiurnal tidal currents. During winter, two fronts separate this well-mixed water from adjacent water masses (Fig. 10). On the southern end of Georges Bank, the shelf-water/slope-water front intersects the bottom at about 80 m and separates cooler, fresher shelf water from warmer, more saline slope water.

On the north side of Georges Bank a second weaker and deeper front separates Georges Bank water from Gulf of Maine water. During summer, a seasonal thermocline develops over the Gulf of Maine, the slope water, and the water deeper than 60 m on the southern flank. A tidally mixed front forms at approximately the 60 m isobath (Fig. 11). A subsurface band of cool water occurs along the southern flank between the 60 m and 100 m isobaths, bounded by the warmer slope water to the south, the warmer, well-mixed Georges Bank water to the north, and the seasonal thermocline above (Butman, et al., 1981). The location of the strong shelf-water/slope-water front varies throughout the year; its mean seasonal position during winter and summer is indicated in Figure 12.

Typical seasonal variations in temperature and salinity throughout the area are indicated in Figures 13 through 18.

Throughout most of the study area strong vertical stratification, which inhibits mixing (high stability), occurs during summer in the upper 40 m followed by a rapid decrease in stability below about 100 m. During the winter, stability is low (strong vertical mixing) in the upper 40 m and attains a maximum at about 70 m. Below about 100 m stability decreases rapidly (Bishop, et al., 1981).

V. CIRCULATION

The study area is a complex physiographic region comprised of distinct topographic regimes. There is the coastal boundary layer, the Gulf of Maine basin, the shelf-break/continental slope, and the shallow topography of the banks. All of these features affect the horizontal and vertical diffusive exchange and horizontal advective exchange in the area. During summer, physical properties are rapidly transferred horizontally as compared to vertical transfer times for the entire region. During winter, convective overturning reduces the time scale for horizontal exchange on Georges Bank and greatly reduces the vertical exchange time scale in the Gulf of Maine (Loder, 1981).

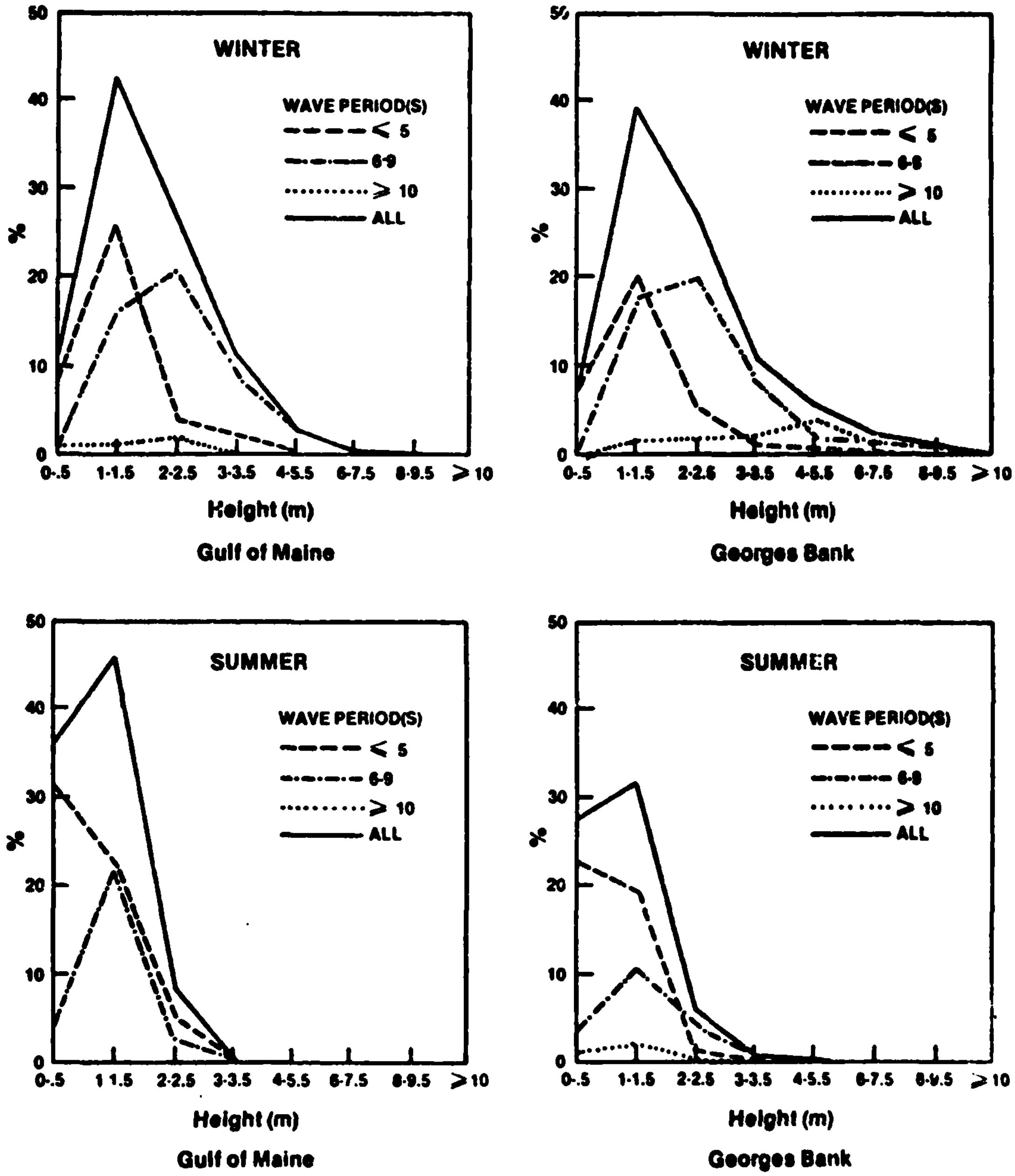


Figure 6. Typical Winter/Summer Wave Height-Period Histograms (Bishop, et al., 1981).

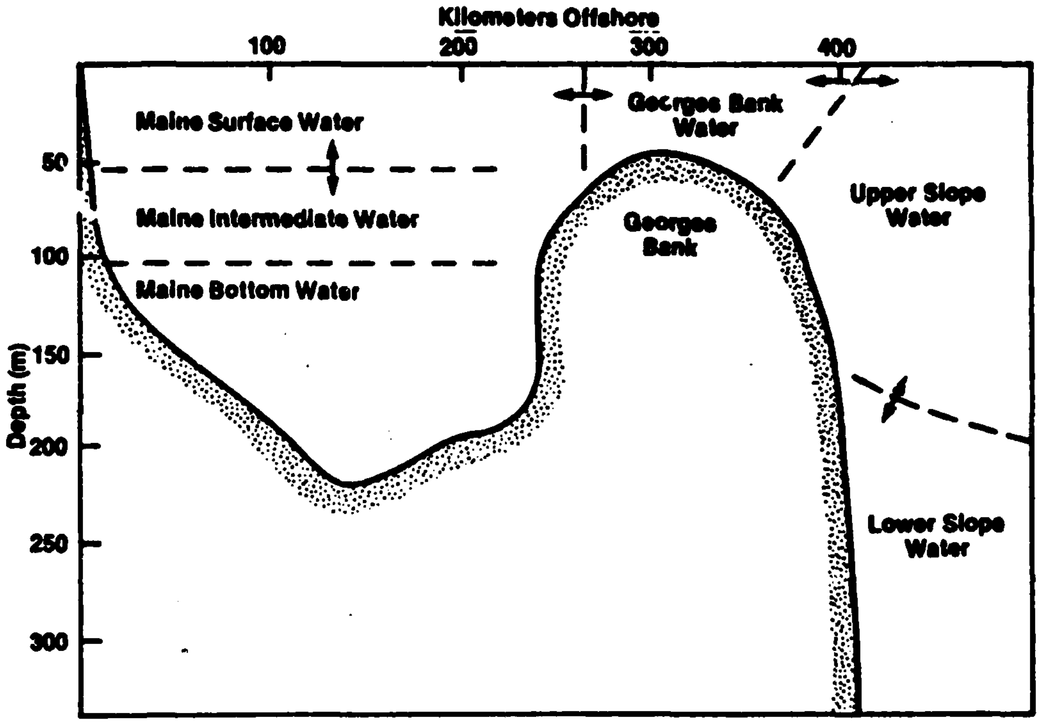


Figure 7. Water Mass Schematic of the Gulf of Maine (Hopkins and Garfield, 1977).

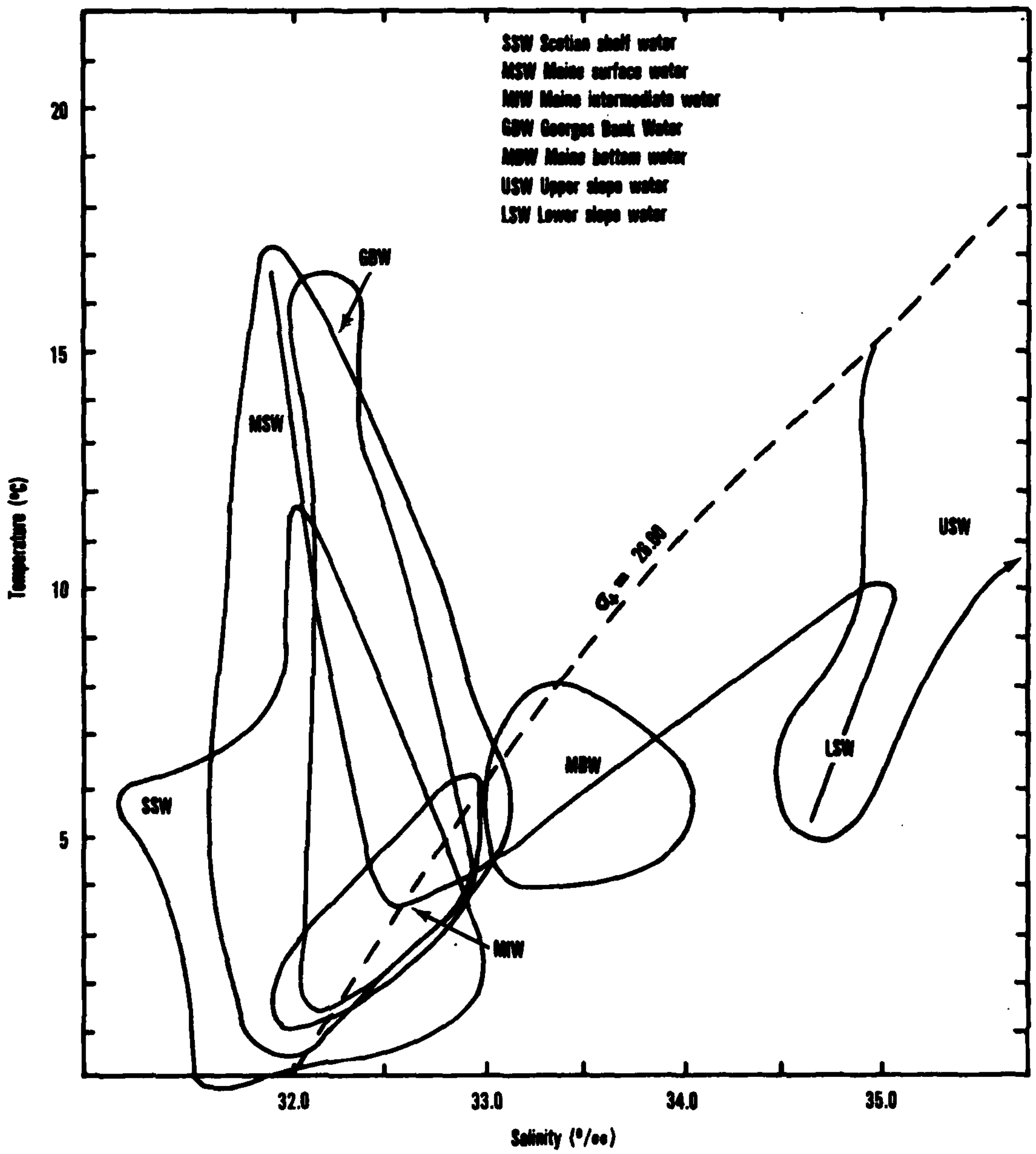


Figure 8. T-S Diagram, Gulf of Maine (Hopkins and Garfield, 1977).

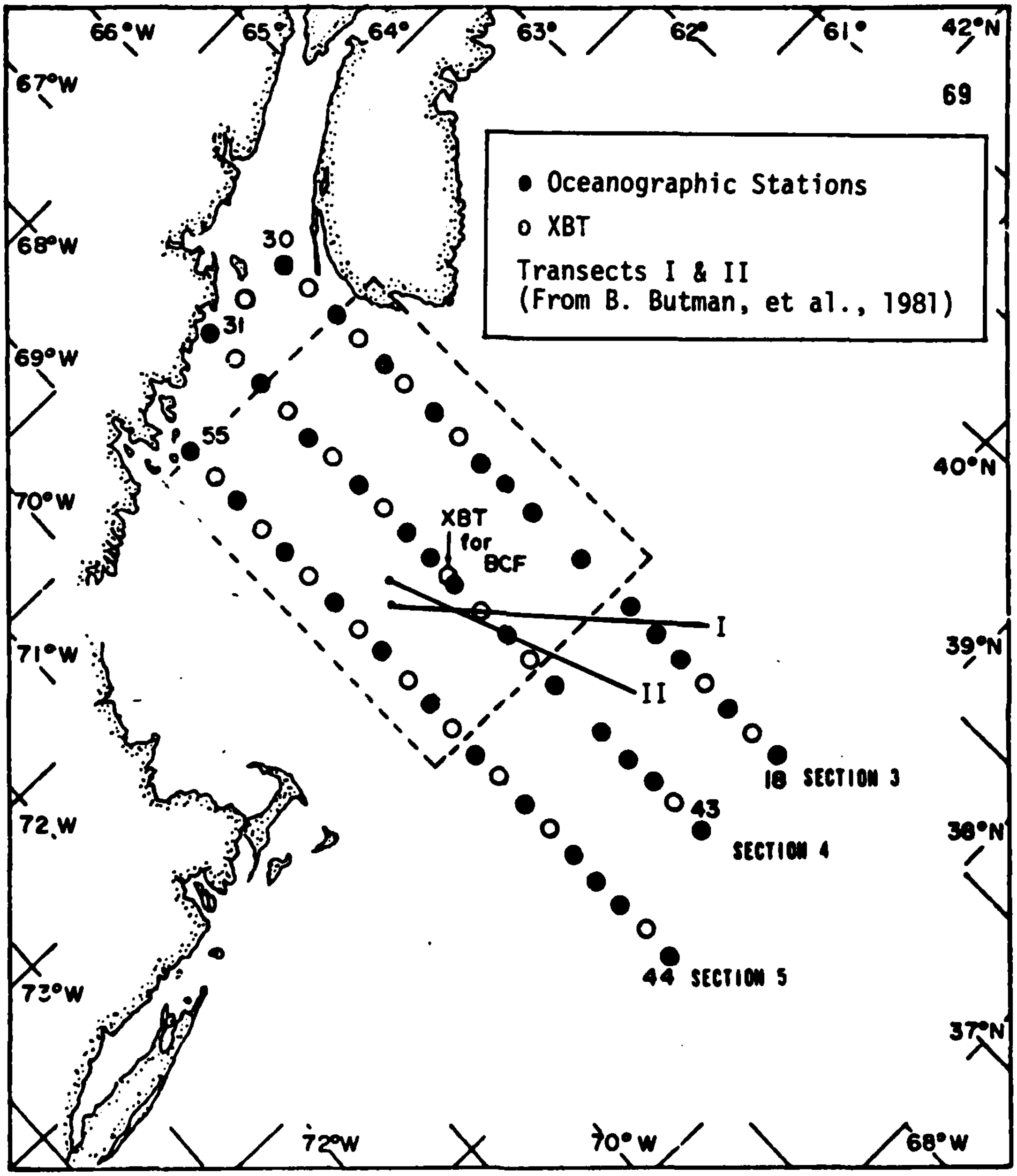


Figure 9. Oceanographic Stations (Light, et al., 1974).

TRANSECT 1

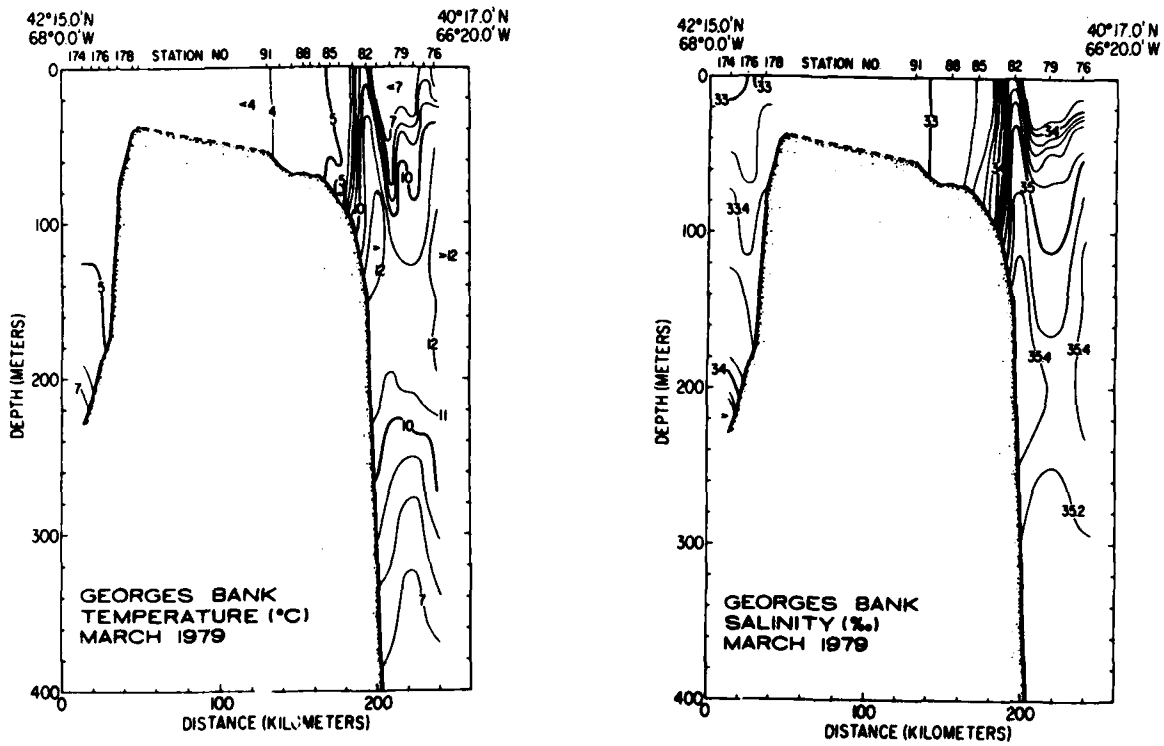


Figure 10. Typical Late Winter Temperature and Salinity Sections (Butman, et al., 1981).

TRANSECT 2

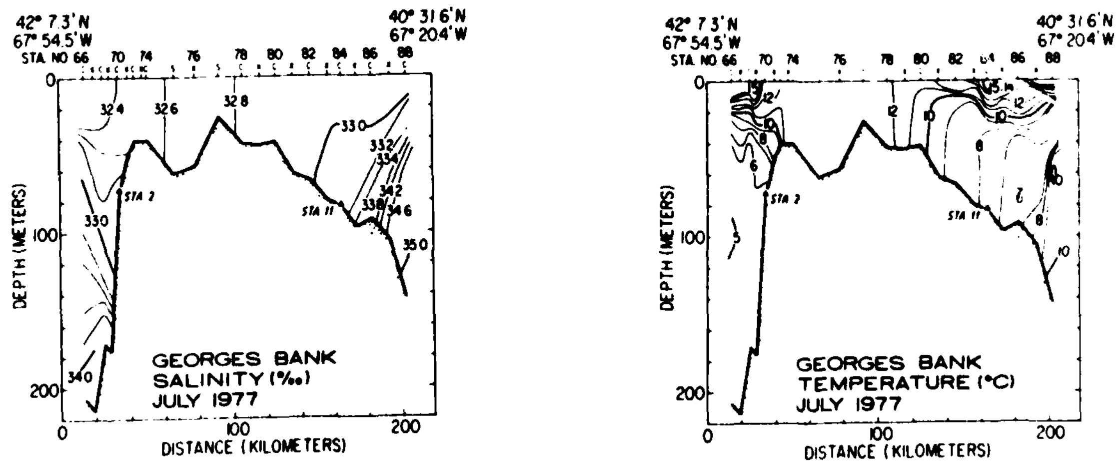


Figure 11. Typical Summer Temperature and Salinity Sections (Butman, et al., 1981).

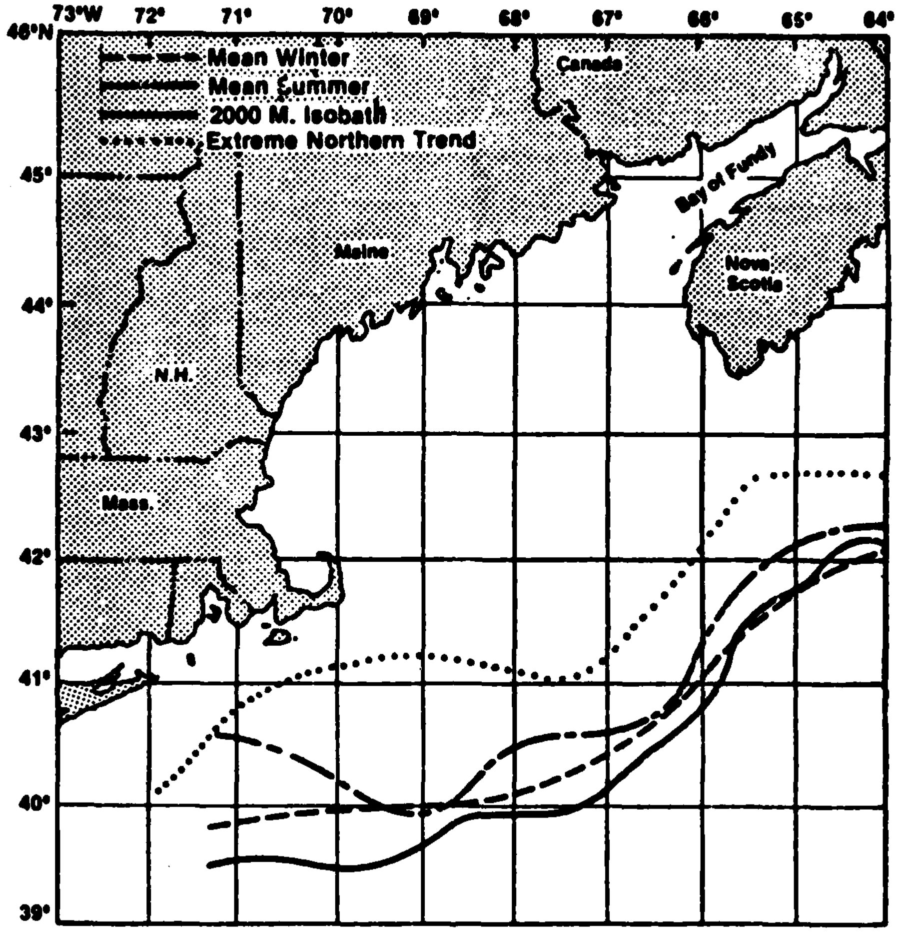


Figure 12. Shelf/Slope Water Frontal Positions (Bishop, et al, 1981).

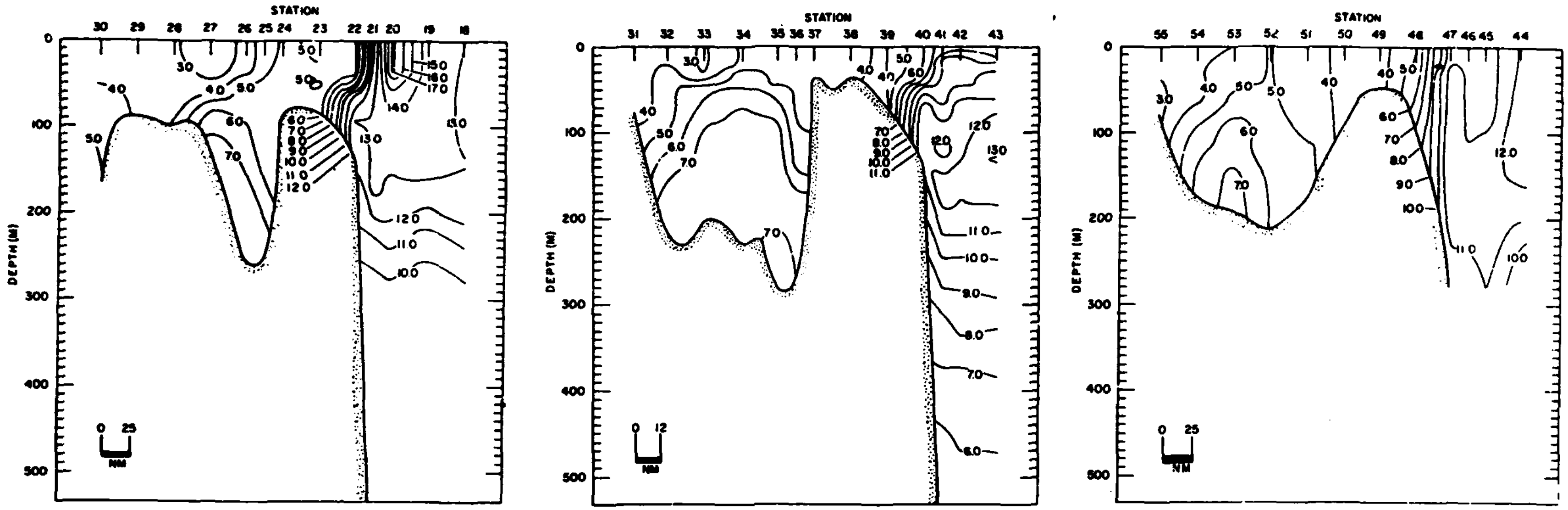


Figure 13. Typical Winter Temperature Sections (Light, et al., 1974).

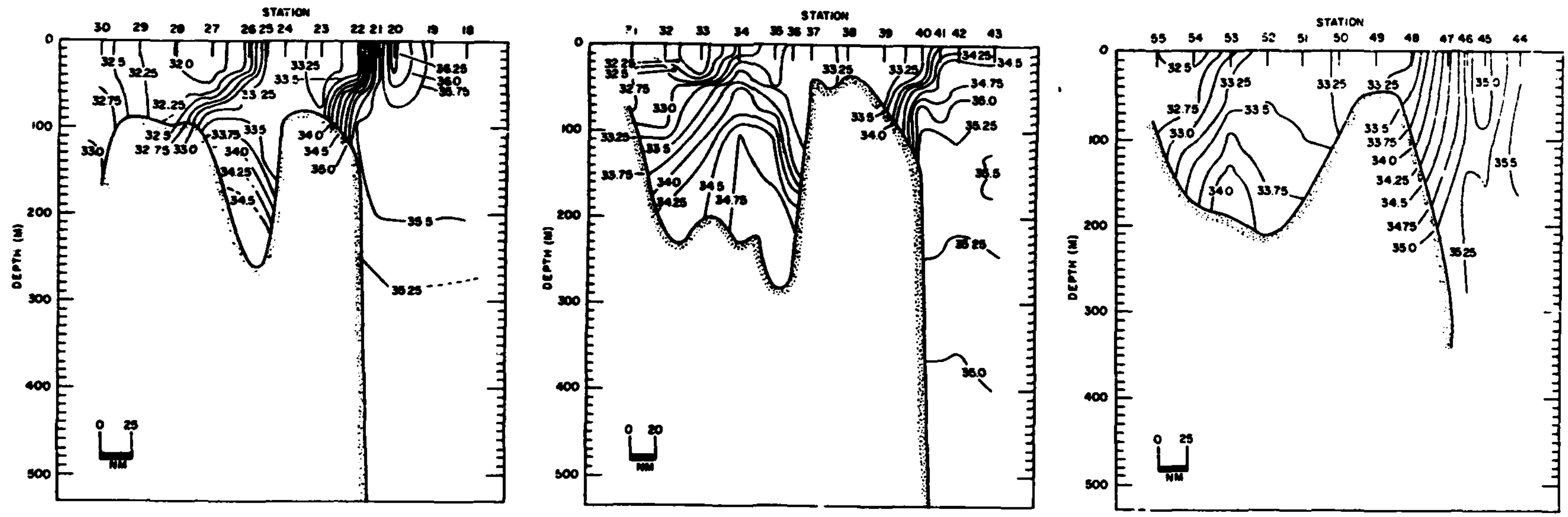


Figure 14. Typical Winter Salinity Sections (Light, et al., 1974).

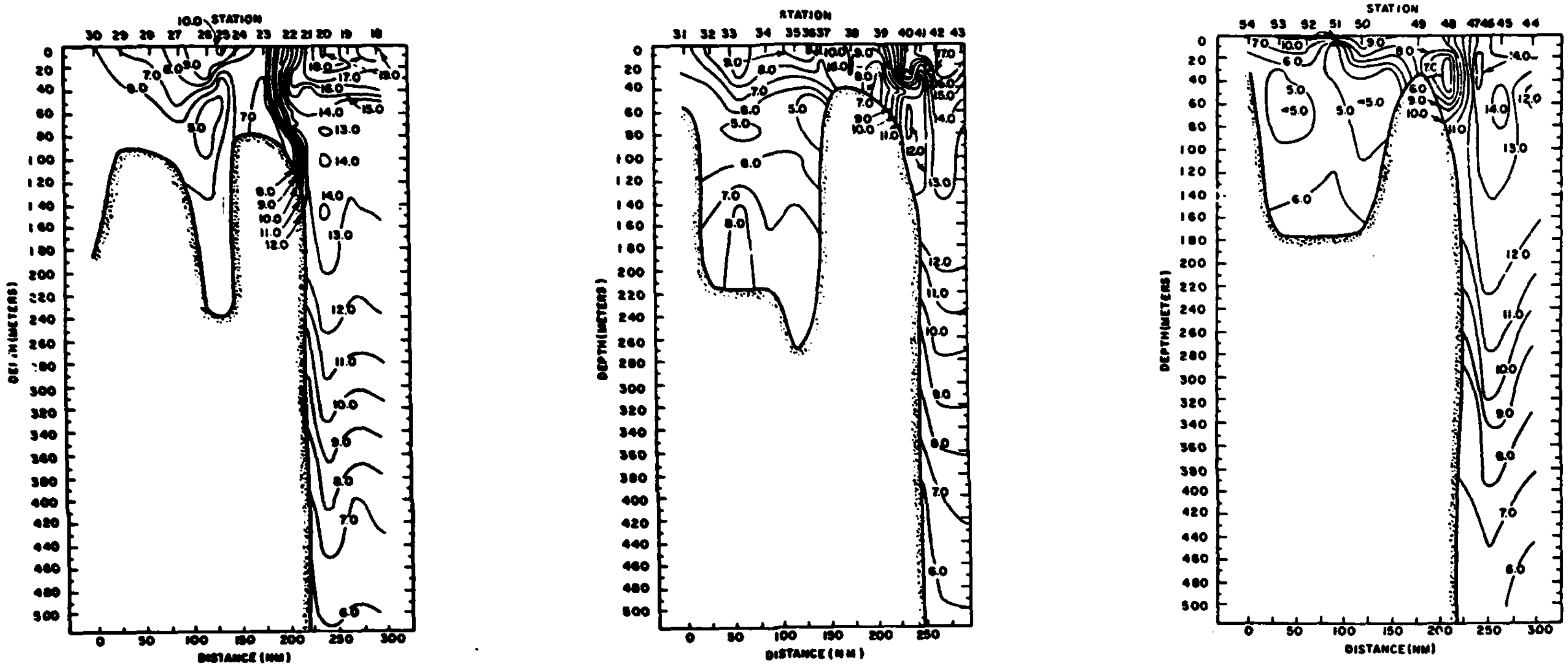


Figure 15. Typical Summer Temperature Sections (Hayes, 1975).

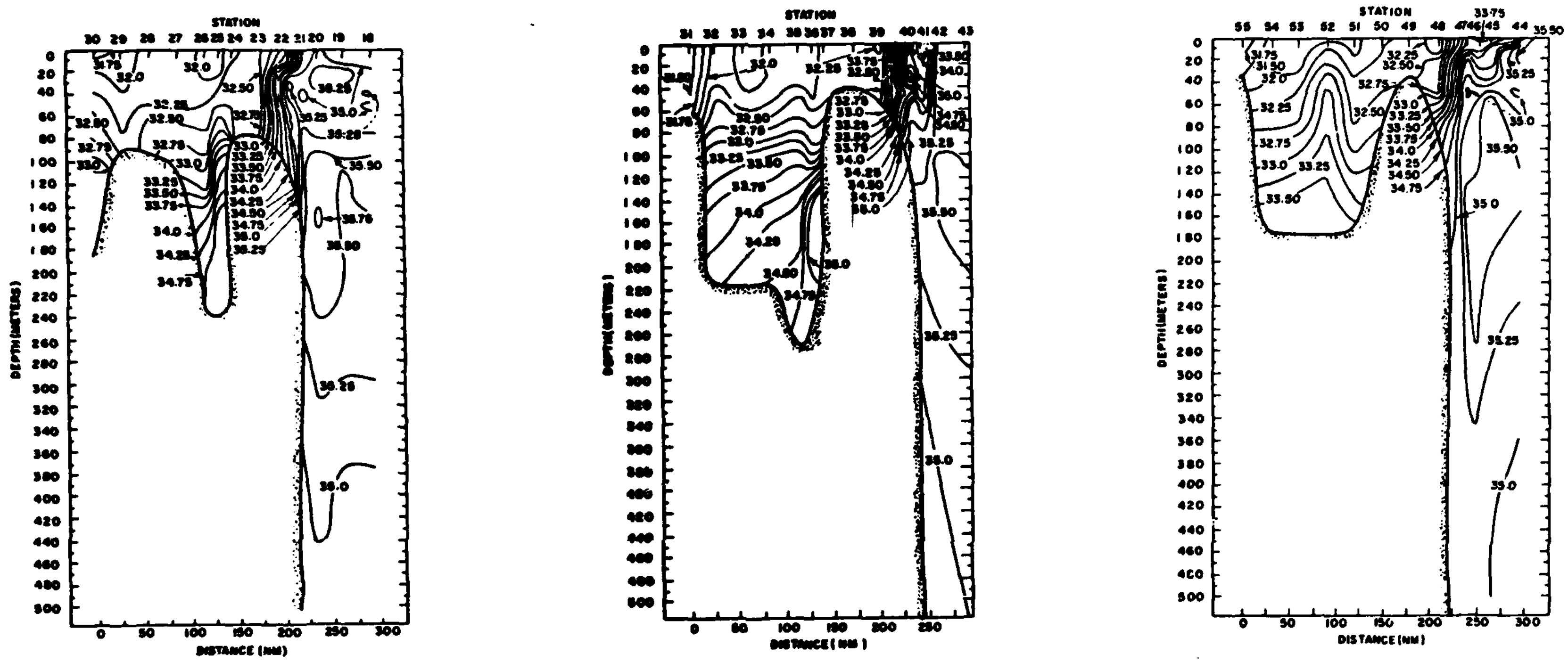


Figure 16. Typical Summer Salinity Sections (Hayes, 1975).

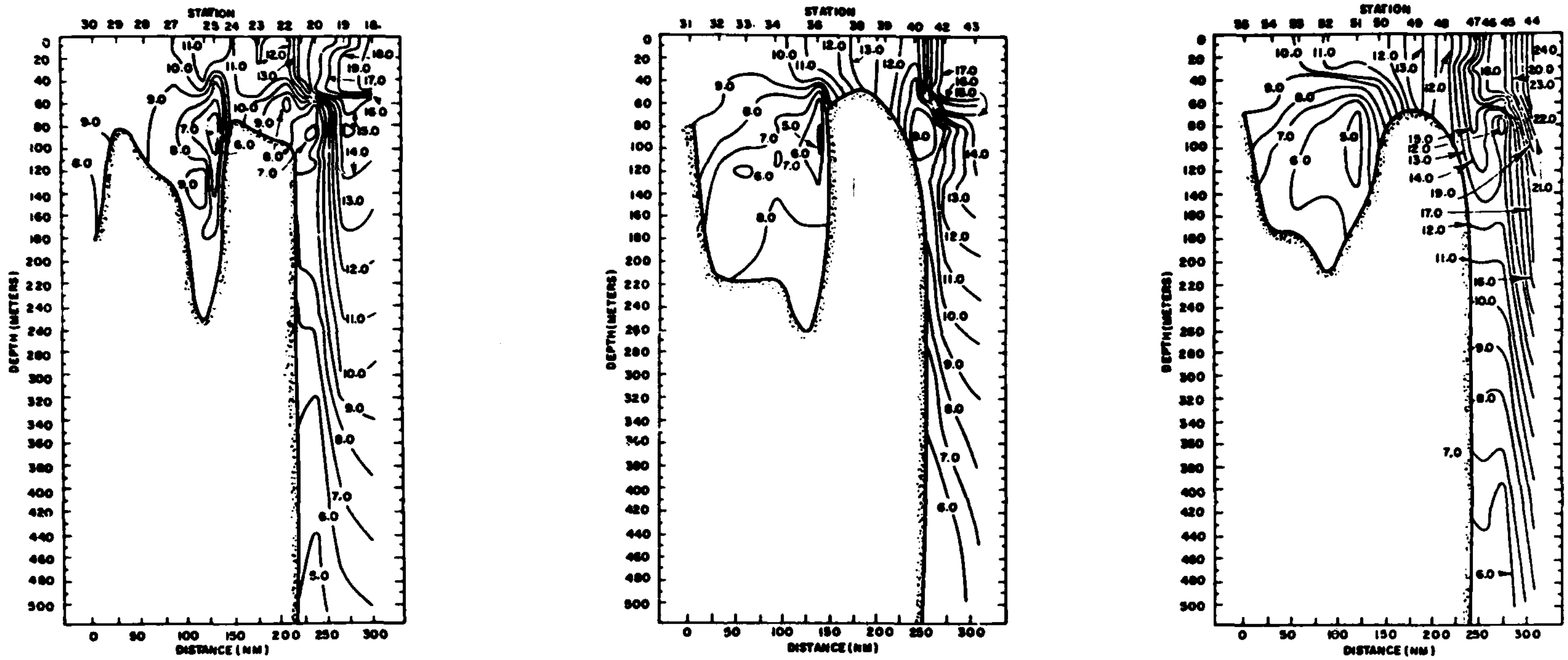


Figure 17. Typical Autumn Temperature Sections (Hayes, 1975).

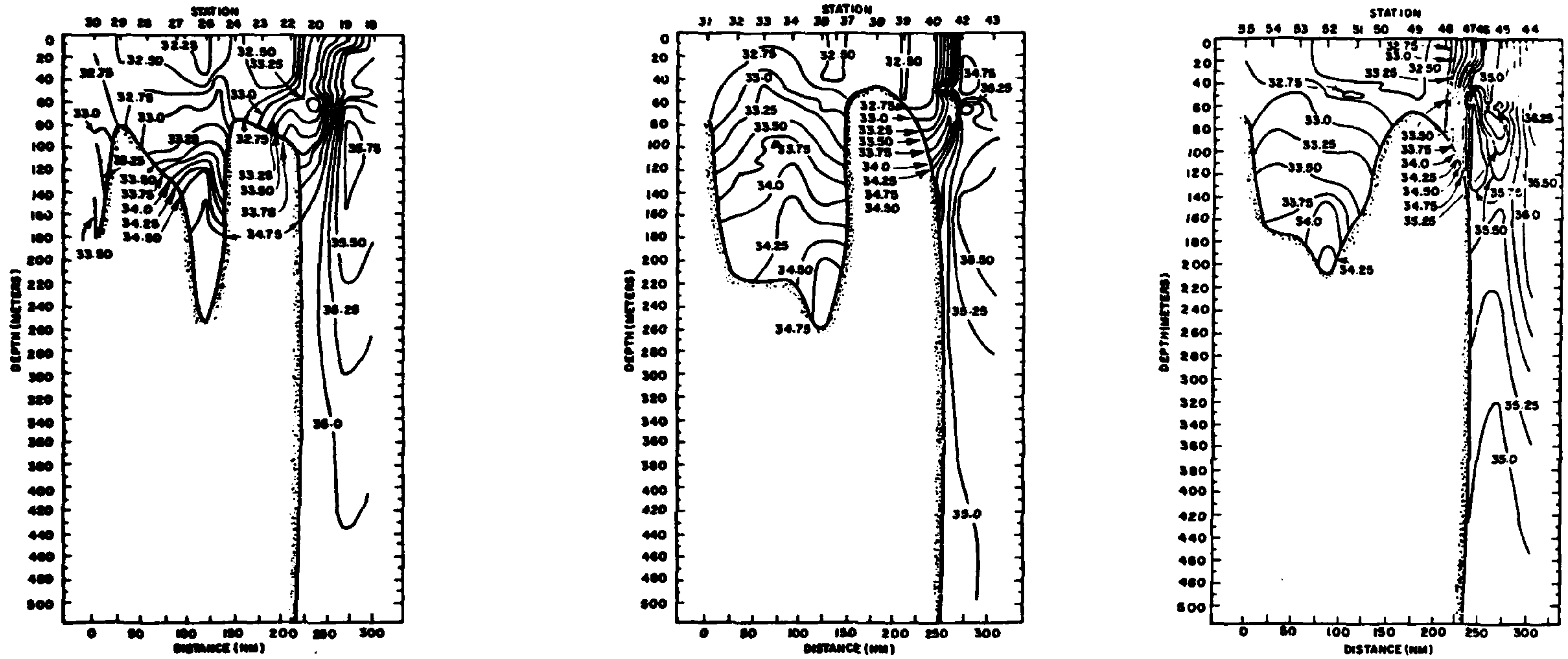


Figure 18. Near Autumn Salinity Sections (Hayes, 1975).

The dominant area-wide advective process that affects the horizontal transfer is the mean circulation, which is strongly controlled by bottom topography and occurs primarily along isobaths.

The dominant near-surface residual circulation (Fig. 19) in the study area consists of a cyclonic flow in the Gulf of Maine and an anticyclonic flow in Georges Bank (Bigelow, 1927). Near-surface speeds of approximately 5-10 centimeters per second (cm/sec) are typical throughout the year with maximum speed attained during spring about 10-15 m below the surface, while during summer and winter the flow is diminished. Flows greater than 10 cm/sec have been reported. Butman, et al. (1981) measured a northeast, narrow, jetlike current of 30 cm/sec along the northern flank of Georges Bank (Fig. 20), and using satellite drifters and current meters, further concluded that the circulation around Georges Bank was not completely closed and considerable variability should be expected.

The current field in the study area may be divided into a seasonal mean flow, low-frequency current fluctuation (associated with density effects, wind stress, topographic waves, and the ocean circulation), diurnal and semidiurnal tidal currents, and higher frequency current fluctuations associated with surface and internal waves.

In water depths shallower than about 60 m, the water column will be vertically well mixed throughout the year due to the strong semidiurnal tidal currents. On the north flank of Georges Bank tidal currents 1 m from the bottom had amplitudes of 30 cm/sec in 60 m of water. In contrast, the tidal currents on the southern flank were about 20 cm/sec in 85 m of water. Figure 21 indicates typical mean subsurface currents throughout the year.

Beardsley and Smith (1981) summarized six years of current meter records, satellite-tracked drifters, and aircraft-tracked drifters as follows:

(1) the counterclockwise Gulf of Maine circulation is a large-scale permanent feature.

(2) the clockwise flow around Georges Bank also is a persistent feature with a jet-like northeasterly flow along the northern flank and a weaker broader southwesterly flow along the southern flank.

(3) There is an intermittent or partial recirculation around the shallower core (less than 60 m) of Georges Bank.

(4) Measurements in Northeast Channel indicate a relatively constant inflow of slope water below 100 m, concentrated on the eastern side.

(5) At the western end of the Scotian Shelf (approx. 43°N, 66°W) inflow occurs into the Gulf of Maine from the surface to mid-depth; a permanent clockwise gyre occurs around Browns Bank.

(6) Subtidal wind-driven circulation at periods from 2 to 10 days and offshore forcing by the Gulf Stream at periods greater than 10 days modify the general circulation pattern at the shelf break southwest of Nova Scotia.

(7) Frontal analysis off Nova Scotia during the summer of 1977 revealed that cold Scotian Shelf Water became entrained around a warm eddy. As the eddy

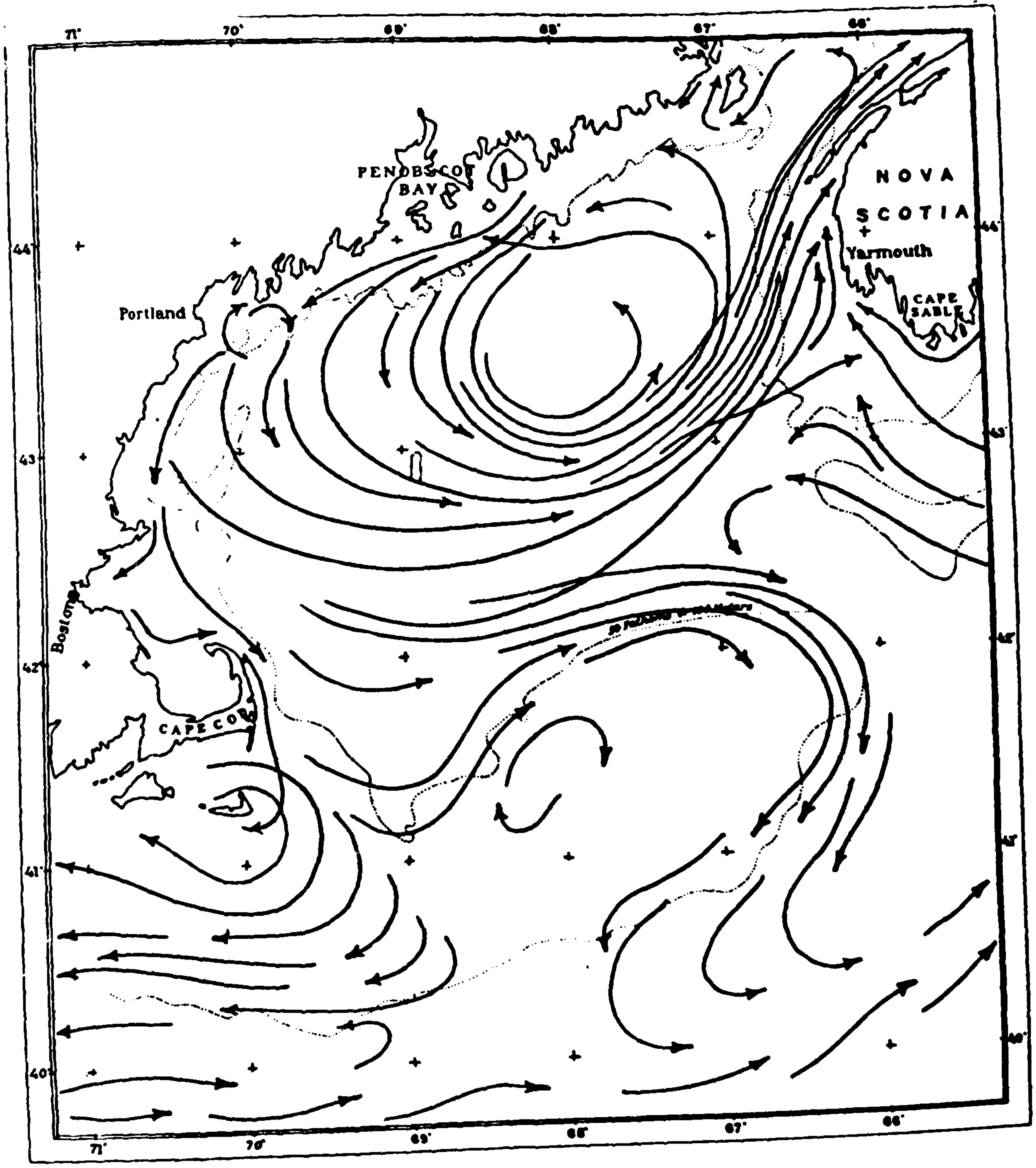


Figure 19. Near Surface General Circulation (Bigelow, 1927).

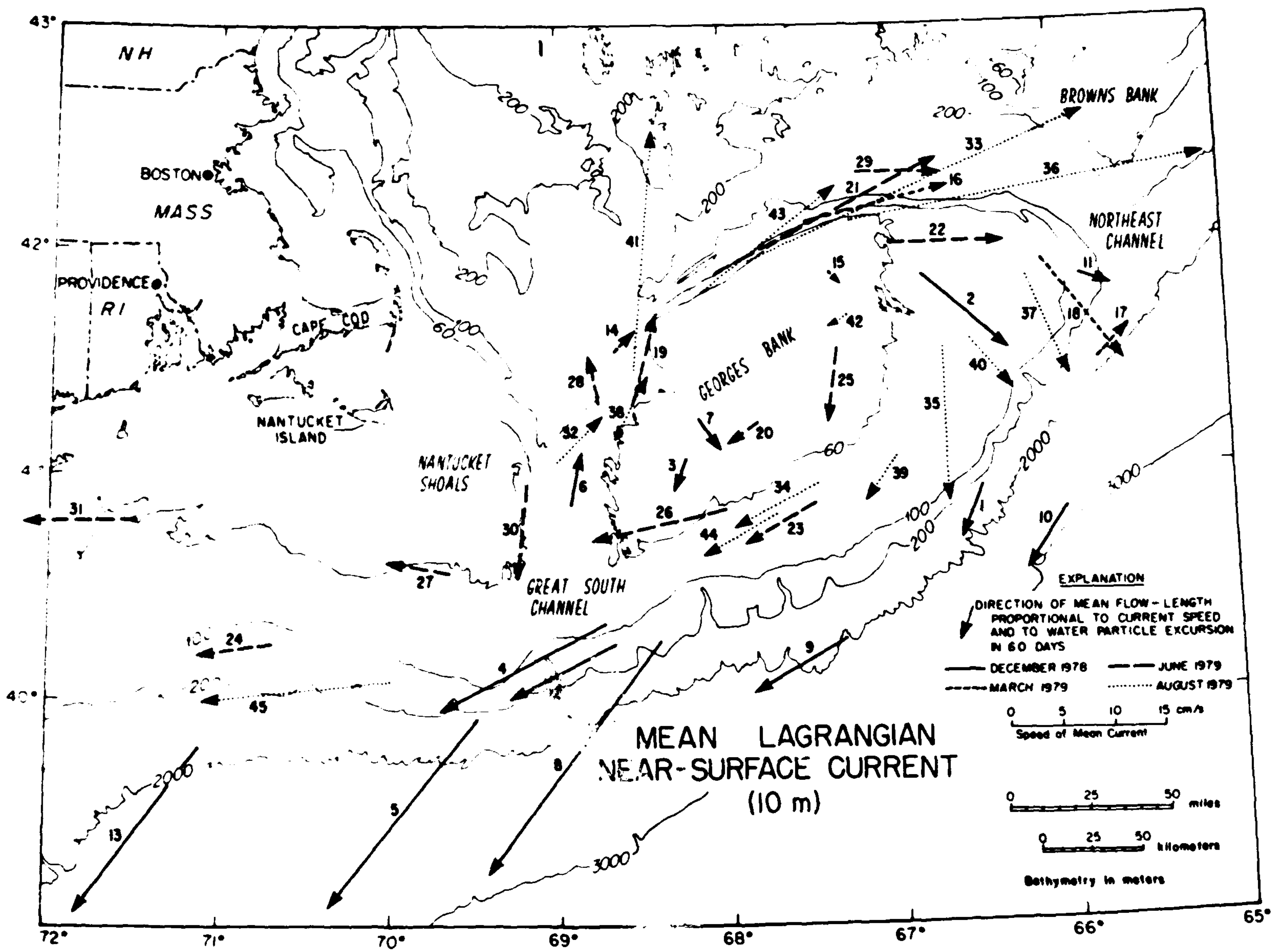


Figure 20. Mean Near Surface Current (Butman, et al., 1981).

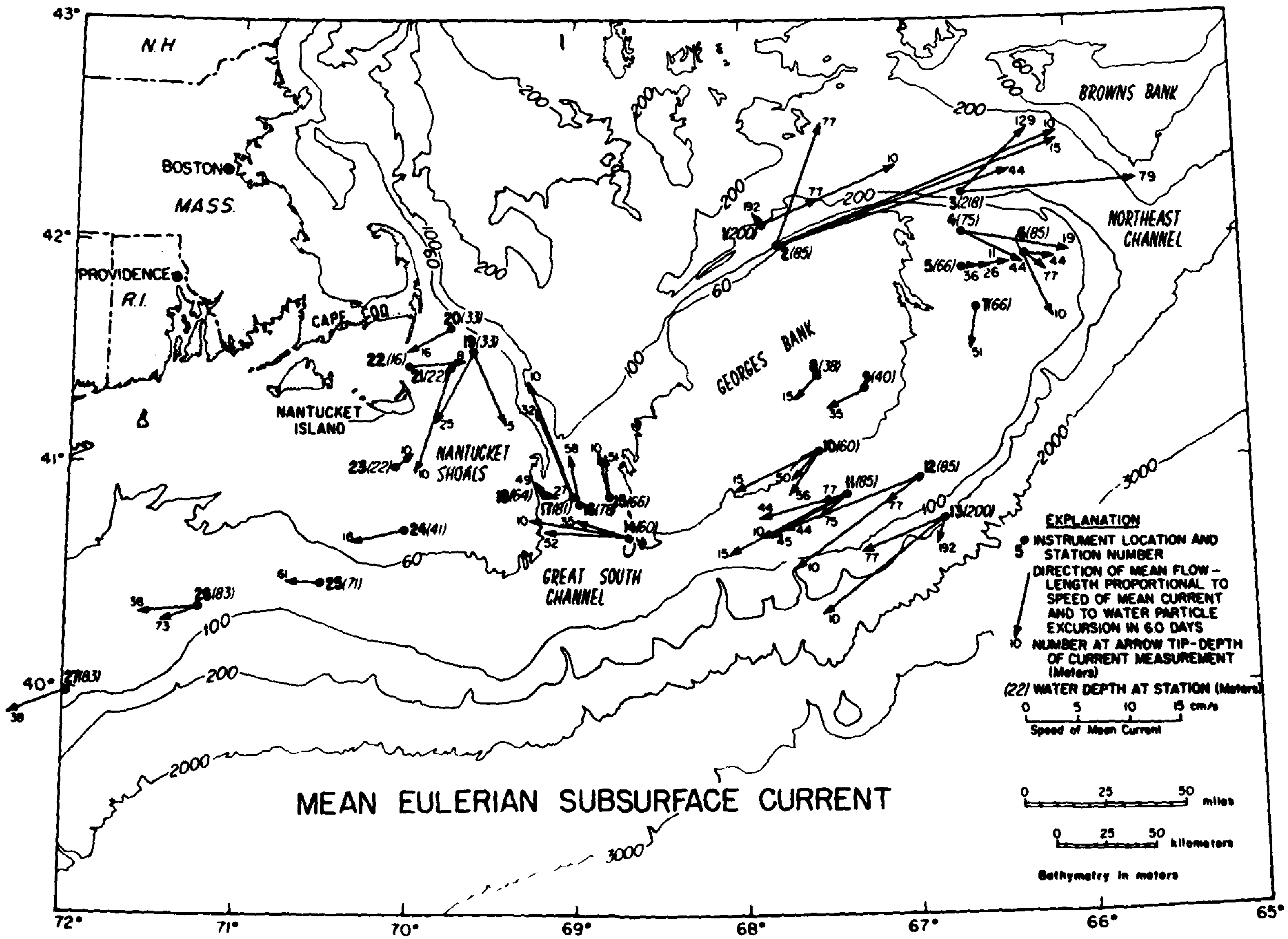


Figure 21. Mean Subsurface Currents (Butman, et al., 1981).

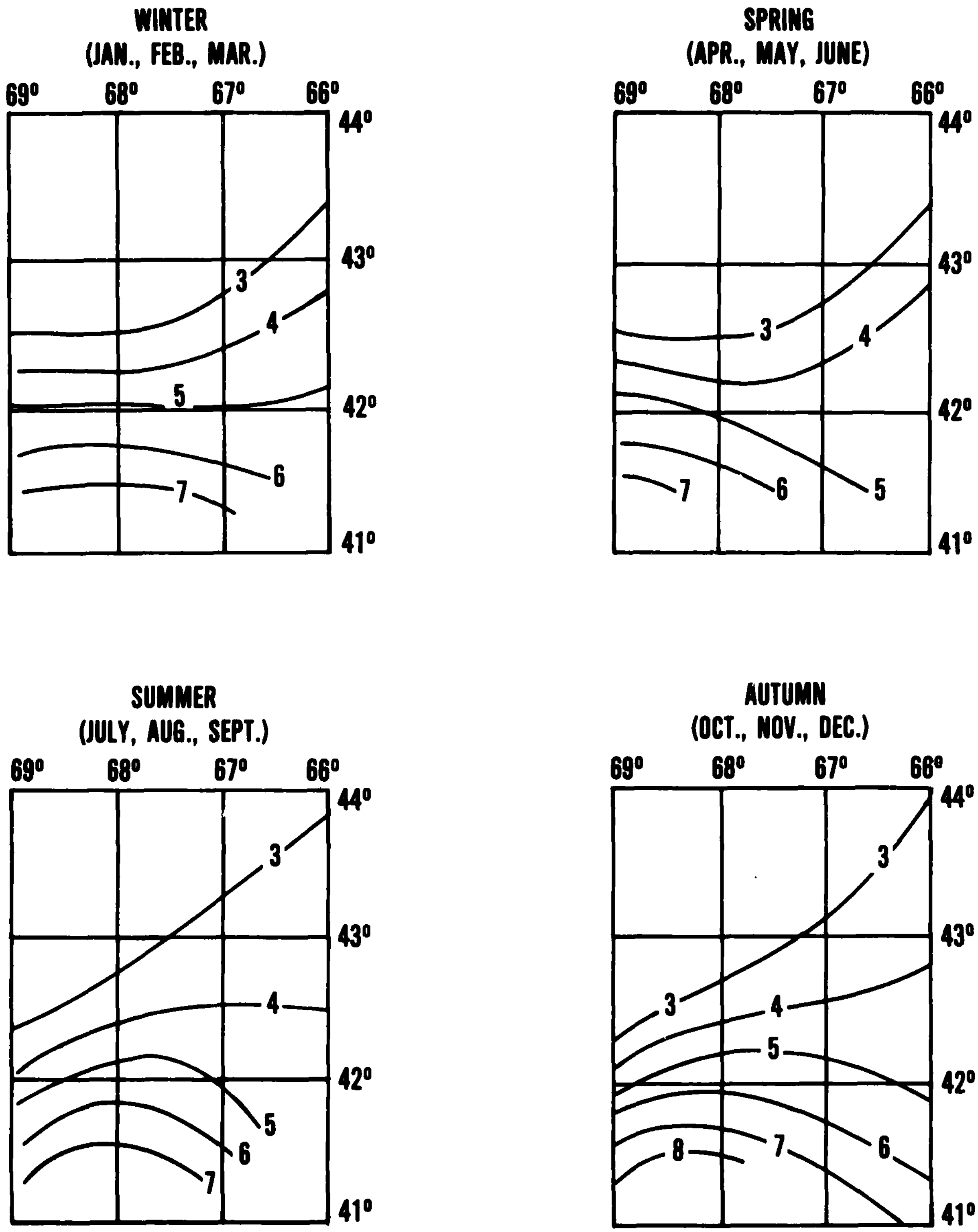


Figure 22. One-Degree Square Weighted Surface Ship Traffic Density.

passed through the region, 14-day oscillations in the long-shore current occurred with peak-to-peak amplitude of 20 to 30 cm/sec with strong horizontal shears.

(8) Persistent (>2 days) strong (>10 m/sec westerly winds may produce transient upwelling at the edge of the Scotian Shelf. On the Scotian Shelf, onshore near-bottom currents in excess of 50 cm/sec were recorded. The T-S properties indicated that the water had upwelled from a depth of 500 m on the continental slope. Data indicated the existence of nonlinear topographic enhancement (channeling) of the onshore flow during 20 occasions in the fall and winter months on the Scotian Shelf.

According to Bumpus (1976) one of the distinctive features of Georges Bank is the strong (up to >100 cm/sec) semidiurnal, clockwise, rotary tidal current flow that has its major axis aligned in a northwest-southeast direction. Since the depth of the major portion of Georges Bank lies between 40 m and 100 m, it provides a sufficiently large obstacle to regional water movement. It is further characterized as a region of thorough vertical mixing throughout the year, particularly in the central part of the bank. This mixed water provides a distinct contrast to the surrounding water masses.

Strong tidal currents may also produce changes in water temperature which may affect the operating characteristics of fixed transducers. In addition to temperature effects, tidal currents may cause flow-induced vibrations of the transducer and its support (Urick, 1975).

Revie, et al. (1971) showed how a bottom-mounted hydrophone responded directly to pressure and temperature changes for periods up to that of the semidiurnal tide (12.42 hours). Since transducer response was independent of flow direction, maxima variations in signal strength occurred about every six hours. It was not stated where the experiment was conducted.

According to Urick (1979) changes in water depth and changes in mean streaming velocity past a transducer, due to tidal action, may result in amplitude and phase distortion of an acoustic signal.

VI. SHIP TRAFFIC DENSITY

Within water depths in excess of 200 m (deep water), both near and distant surface shipping traffic is considered as a potential source of ambient noise in the decade 50 to 500 Hz. In shallow waters (depths less than 200 m) distant surface ship traffic is usually excluded as an ambient noise source (Urick, 1975).

Although most of the study area has depths less than 200 m, the region is considered acoustically deep because of the presence of strong internal sound channels in the Gulf of Maine and the Scotian Shelf (Urick, 1979).

Contours of one-degree square weighted surface ship traffic density are shown in Figure 22. Data are from NORDA's Historical Temporal Shipping (HITS-II, 1980) computer file as described by Jacobs (1981). The contours represent the mean, or average, number of model ships to be found at any given time in the area, a model ship being a composite vessel profile made up from several weighted ship profiles that include tankers, merchant vessels, and fishing trawlers. The weighted model ship number is used as an input variable to ambient noise computer models. Highest ship traffic appears to be concentrated south of about 42.5°N throughout the year.

VII. SUMMARY

The Gulf of Maine/Georges Bank region contains a highly dynamic oceanographic environment which supports a richly productive biological community. Throughout most of the waters of the area extensive vertical mixing, as a result of strong tidal currents and wind stress, extends down to at least 60 m throughout the year. On the crests of bank areas, such as Georges Bank, vertical mixing may extend to deeper depths, particularly during late winter (March) when it may extend to or near the bottom. This well-mixed water column, which is in sharp contrast to the shelf/slope water immediately to the south of Georges Bank, forms a permanent frontal zone that occupies the southern sector of the study area and migrates seasonally. Weaker tidally induced fronts may occur on the northern flank of Georges Bank and at other locations. On the northern flank of Georges Bank strong rotary tidal currents may occur throughout the water column. Transient upwelling in the vicinity of the Scotian Shelf and Georges Bank should be expected during times of persistent westerly winds. During the winter, Georges Bank, due to its longer fetch from the west and northwest, experiences somewhat higher wave heights at all periods.

Using only these environmental data as a guide, the most satisfactory exercise area would appear to be north of Georges Bank, i.e., in the Gulf of Maine north of 42°N and west of 67°W.

VIII. REFERENCES

Beardsley, R.C. and P.C. Smith (1981). The Mean, Seasonal and Subtidal Circulations in the Georges Bank and Gulf of Maine Region. Third Informal Workshop on the Oceanography of the Gulf of Maine and Adjacent Seas. University of New Hampshire, Durham, N.H., March 2-5, 1981, p. 9-16.

Bigelow, H.B. (1927). Physical Oceanography of the Gulf of Maine. U.S. Bur. Fish., 40(1924) Pt. II. Doc. No. 969:511-1027.

Bishop, J.M., D. Harrigan, and V. Mello (1981). A Climatological Oil Spill Planning Guide No. 2 Gulf of Maine/Georges Bank. Federal Emergency Management Agency. Report to Regional Response Team, Coastal Regional I, First Coast Guard District. DTIC Accession No. ADA 103818, 179 p.

Bumpus, D.F. (1976). Review of the Physical Oceanography of Georges Bank. ICNAF Bulletin Number 12, p. 119-134.

Butman, B., R.C. Beardsley, B. Magnell. J.A. Vermersch, R. Schlitz, R. Limeburner, W.R. Wright, and M.A. Noble (1981). The Mean Circulation on Georges Bank. Woods Hole Oceanog. Instit., Contribution No. 4722 (submitted to Journal of Physical Oceanography).

Godshall, F.A., R.G. Williams, J.M. Bishop, F. Everdale, and S.W. Fehler (1980). A Climatologic and Oceanographic Analysis of the Georges Bank Region of the Outer Continental Shelf. Final Report to the Bureau of Land Management, U.S. Department of the Interior, Interagency Agreement AA 551-IA8-14, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data and Information Service, Washington, D.C., 290 p.

Hayes, R.M. (1975). Oceanographic Report No. CG 373-66. Oceanographic Observations Nova Scotia to Cape Hatteras, North Carolina, October-November 1969 and May-June 1970. United States Coast Guard Oceanographic Unit, Washington, D.C., DTIC Accession No. ADA 020308, 239 p.

Hopkins, T.S. and N. Garfield (1977). The Existence of the Maine Intermediate Water. In: A Summary of an Informal Workshop of the Physical Oceanography of the Gulf of Maine and Adjacent Seas. Woods Hole Oceanog. Instit., 28 p.

Jacobs, G. (1981). HITS-II Shipping Data (Revision of memo of November, 1981). Ocean Data Systems, Inc. Internal memorandum, Ocean Data Systems, Inc.

Light, M. and S.J. Henderson (1974). Oceanographic Report No. CG-373-65. Waters in Support of the International Commission for Northwest Atlantic Fisheries, January 1968; January-February 1969. United States Coast Guard Oceanographic Unit, Washington, D.C. DTIC Accession No. ADA 002265, 149 p.

Loder, J.W. (1981). Vertical and Horizontal Transfer Processes in the Gulf of Maine. Third Informal Workshop on the Oceanography of the Gulf of Maine and Adjacent Seas. University of New Hampshire, Durham, N.H., March 2-5, 1981; p. 17-20.

Pawlowski, R.J. (1978). The Gulf of Maine Temperature Structure Between Bar Harbor, Maine, and Yarmouth, Nova Scotia, June 1975-November 1976. NOAA Report No. NOAA-TR-NMFS-SSRF-726, 19 p.

Revie, J. and D.E. Weston (1971). Hydrophone Signals Due to Tidal and Wave Effects. Deep Sea Res. 18(5):545-546.

Urick, Robert J. (1975). Principles of Underwater Sound. New York, McGraw-Hill Book Company, 384 p.

Urick, Robert J. (1979). Sound Propagation in The Sea. Washington, D.C., DARPA, Defense Advanced Research Projects Agency.

Yao, J.Z. and A.E. Barnes (1975). On the Estimation of Shipping Densities From Observed Data. Prepared for Office of Naval Research Code 102-OSC: LRAPP, Contract No. N00014-73-C-0223, PSI TR-0040 18, Planning Systems, Inc., McLean, Va.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NORDA Technical Note 157	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* Physical Oceanographic Summary for the Gulf of Maine/Georges Bank		5. TYPE OF REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Donald A. Burns		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Ocean Research and Development Activity Ocean Science and Technology Laboratory, Code 330 NSTL Station, MS 39529		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE September 1982
		13. NUMBER OF PAGES 27
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Unlimited

DISTRIBUTION STATEMENT A

Approved for public release;
Distribution Unlimited

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Gulf of Maine	Marine Climatology	Sound Channel
Georges Bank	Surface Waves	Fronts
Temperature	Water Masses	Shelf/Slope Water
Salinity	Ship Traffic Density	
Currents	Circulation	

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

~~I provide~~ The Naval Research Laboratory is provided with oceanographic environmental data to support an acoustical experiment in the Gulf of Maine/Georges Bank region. I discuss marine climatology, surface waves, water masses, circulation, and ship traffic density. Using these environmental data as guides, I recommend that the most satisfactory exercise area would be north of Georges Bank, i.e., in the Gulf of Maine north of 42°N and west of 67°W.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

S/N 0102-LF-014-6601

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

END

FILMED

1-83

DTIC